MACHINE-ASSISTED METHOD OF REMOVING UNMARKETABLE PETIOLES FROM CELERY STALKS

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UNITED STATES DEPARTMENT OF AGRICULTURE
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By Frederick E. Henry[1]

ABSTRACT

A machine-assisted method of removing petioles from celery stalks is described. The method consists of making successive cuts through the butt end of the stalk perpendicular to the axis and causes no adverse effects on stalk size or on petioles remaining on the stalk after stripping. Compared with hand stripping, labor costs can be reduced by one-third with the machine-assisted method. This means a saving of $30,000 annually for a packinghouse handling celery stalks at a rate of 200 per minute.

INTRODUCTION

Celery production in Florida has undergone a transition from hand harvesting and packing in the field to mechanical harvesting. When celery was harvested by hand, the stalks were cut at ground level by workers preceding a mobile packing facility commonly referred to as a mule train. The harvesting workers also removed later unmarketable petioles from the stalks and placed the stalks on wing conveyors (fig. 1) leading to the mule train, where they were washed, graded, and packed in crates by other workers (fig. 2).

Mechanical harvesting has necessitated that the celery stalks be transported in bulk to a central location before packing. The bulk trailers used to haul the stalks from the field to the central packinghouse are usually self-unloading—either by tilting the trailer and allowing the stalks to slide out en masse or by a conveyor built into the bed of the trailer.

After the celery stalks are unloaded, they are conveyed into the packinghouse, where unmarketable petioles are removed. The stalks are then cut to a uniform length, washed, sorted into size categories, and packed.

The operation requiring the most labor is removal of unmarketable petioles, or stripping, as it is commonly called. Figure 3 shows a typical celery stripping line in a commercial packinghouse. Workers select a stalk from the waist-high conveyor, remove the unmarketable petioles, and place the stalk on the upper conveyor leading to the washer. This research effort was undertaken to reduce labor costs in this area and to investigate various methods of stripping celery stalks mechanically.

FIGURE 1.—Workers cutting stalks and placing them on wing conveyor.

FIGURE 2.—Workers packing celery on mobile packing facility.

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The operation requiring the most labor is removal of unmarketable petioles, or stripping, as it is commonly called. Figure 3 shows a typical celery stripping line in a commercial packinghouse. Workers select a stalk from the waist-high conveyor, remove the unmarketable petioles, and place the stalk on the upper conveyor leading to the washer. This research effort was undertaken to reduce labor costs in this area and to investigate various methods of stripping celery stalks mechanically.

FIGURE 1.—Workers cutting stalks and placing them on wing conveyor.

FIGURE 2.—Workers packing celery on mobile packing facility.

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FIGURE 3.—Typical celery stripping area in commercial packinghouse.

STRIPPING REQUIREMENTS

The main reasons for stripping celery stalks are to remove damaged or diseased petioles and to shape the stalk so that it is nearly cylindrical, with all remaining petioles closely bunched. This usually requires removing from 1 to 10 or 12 petioles. Figure 4 shows two stalks that have been stripped and are ready to have the tops cut to uniform length. Figure 5 shows a stalk requiring little stripping. The broken petioles on the left and right will have to be removed, plus one or two others at the left rear. These petioles can be removed quickly with two or three hand motions. Many petioles will have to be removed from the celery stalk shown in figure 6, however, which will require several hand motions to complete.

Grizzell and Henry[2] reported that 24 workers would be required for a stripping line processing 200 stalks per minute. At this rate, each worker would strip 8.5 stalks per minute. Subsequent studies of stripping operations have generally confirmed these figures. Under commercial conditions, a qualified worker can average approximately 8 stalks per minute, with a range of 4 or 5 to 14 stalks per minute, depending on the condition of the stalks.

Veal[3] working with hand-cut celery stalks in the field reported an average of 9.58 unmarketable petioles per stalk. When stalks are hauled in bulk to the packinghouse, they have a tendency to become entangled, and some outer petioles are broken off during transport and unloading, so that by the time they reach the stripping-line workers they contain only an average of 6 or 7 unmarketable petioles each.

FIGURE 4.—Stripped celery stalks.

FIGURE 5.—Unstripped celery stalk requiring removal of very few petioles.

[2]Grizzel, W. G., and Henry, F. E. 1971. A central packing-precooling system for celery. U.S. Dep. Agric. Mark. Res. Rep. 869, 34 pp.

[3]Veal, C. D. 1966. Some physical properties of celery as they affect mechanical removal of petioles. 52 pp. Master's thesis, University of Florida.

FIGURE 6.—Unstripped celery stalk requiring removal of many petioles.

MECHANICAL STRIPPING

Laboratory Studies

Veal suggested several possible methods of mechanicaly removing unmarketable petioles from celery stalks. Two of the more promising suggestions were tried.

The first was to strike a blow on the butt end of the unstripped stalk. This was accomplished by dropping the stalk through a section of 10-inch-diameter duct onto a hard surface. This method effectively removed most of the unmarketable petioles, but also cracked good petioles located near the center of the stalk. Small, limber petioles attached to some stalks were not removed by this method. When the distance the stalks were dropped was such that good petioles were not damaged, unmarketable petioles were not removed effectively.

The second method was to place unstripped celery stalks in a drum mounted to permit rotation. When the drum was rotated about its axis, it produced no effect whatesover on the stalks. When the drum was rotated end-over-end, the stalks became hopelessly entangled and were damaged to the point that all of the stalks were unmarketable.

During these early tests, it was noted that unmarketable petioles could be removed from a stalk by making one cut through the stalk, perpendicular to its axis, at the right location. This method is effective because new growth begins at the center of celery stalks and the bases of the outside petioles are located lower than the newer center growth.

Figure 7 shows a celery stalk stripped by the above method. The stalk was cut perpendicular to its axis at a point where the outside petioles would be detached, leaving the well-shaped stalk in the center. Extreme care must be used with this method of stripping, because if the cut is made too high on the stalk, good petioles will be removed and the stalk size will be unnecessarily reduced. A cut too high can render the entire stalk unmarketable.

Field Studies

Because of problems in alinement and the skill required in selecting the exact point where the stalk should be cut, it was decided to make several cuts across the axis of the stalk, starting at the butt end. With this method, one or two petioles would be removed at a time and cutting could be stopped as soon as the stalk was properly shaped.

Equipment was designed and built to field-test this method (fig. 8); it consisted of a conveyor belt with a powered cutter blade and safety housing attached to the rear. Figure 9 shows a closeup of the cutter blade and safety housing.

In the field test, the worker grasped a stalk of celery as it approached on the conveyor and rested the butt end on the support in front of

FIGURE 7.—Celery stalk stripped by making one cut perpendicular to its axis.

FIGURE 8.—Experimental equipment for mechanical stripping of celery stalks.

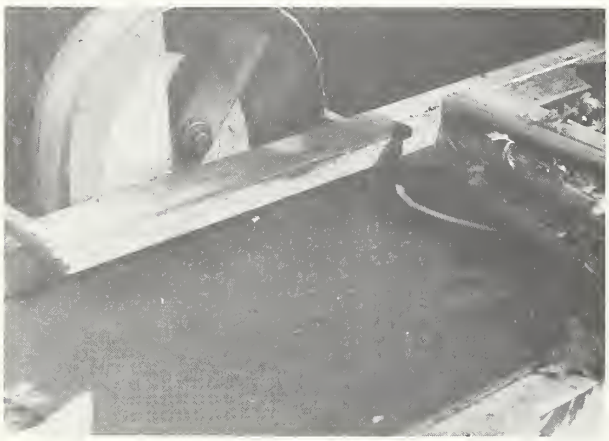

FIGURE 9.—Cutter blade and safety housing of experimental mechanical celery stripper.

the rotating cutter blade. He then pushed the butt into the path of the blade. As the stalk continued forward, successive slices were made across the stalk butt and lower petioles. When enough petioles had been removed and the stalk was properly shaped, the worker removed the stalk and allowed the loose petioles to drop onto the conveyor belt.

To determine if this method of stripping unduly reduced the finished stalk size, thus reducing gross income for the grower, it was compared with hand stripping. A quantity of celery stalks was selected at random and hand-stripped. The initial and final weight of each stalk was recorded. A like number of stalks were stripped using the experimental equipment, also recording the initial and final stalk weights.

Figures 10 and 11 are frequency distributions of the initial and final stalk weights for hand- and machine-stripped stalks. In both cases the largest stalks were reduced in weight from almost 5 pounds to slightly over 3 pounds, and the smallest, from 1.5 pounds to 1 pound. This shows a closer grouping in the stripped stalk weights for both methods of stripping and also indicates that more petioles were removed from the larger stalks in both cases. It is highly probable that some of the smaller stalks had been partially stripped during transport from the field or unloading.

The initial versus final weights of each stalk were also plotted for both hand and machine stripping and the curves are shown in figures 12 and 13. Visual inspection of the two curves indicates good correlation of the two stripping methods. Statistical analysis of the data obtained from both the machine- and hand-stripping methods also showed no differences between either the variances or means at the 2½ percent confidence level.

Another point of major concern was whether or not the petioles remaining on a machine-stripped celery stalk would be unduly loosened. It had been generally thought in the industry that the butt of the stalk, when stripped, should protrude at least one-fourth inch below the lowest petiole for support. Otherwise the petiole would become detached from the stalk during subsequent handling.

To test this thesis, celery stalks were randomly selected and hand-stripped with the butt left

FIGURE 10.—Frequency distribution of initial and final stalk weights for hand-stripped celery stalks.

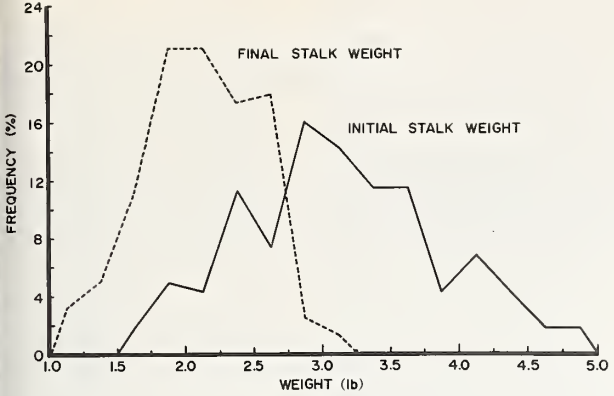

FIGURE 11.—Frequency distribution of initial and final stack weights for machine-stripped celery stalks.

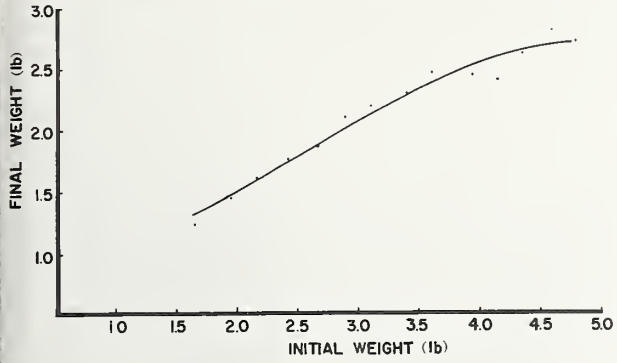

FIGURE 12.—Initial versus final stalk weight (hand stripping).

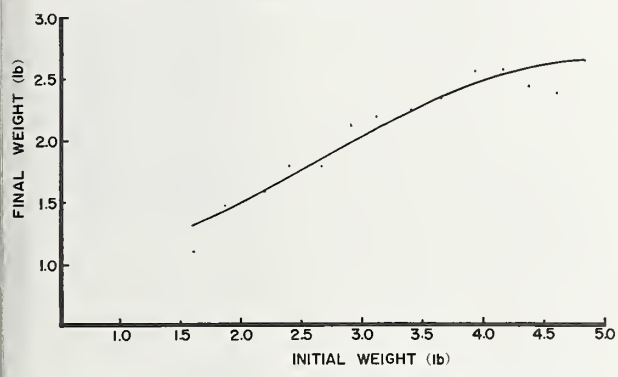

FIGURE 13.—Initial versus final stalk weight (machine stripping).

protruding below the base of the lowest petiole. A perpendicular force was then applied to a point 8 inches above the base of the outside petiole on each stalk. The force was increased until the petiole broke away from the stalk, and its magnitude was recorded. The width of the petiole at its base was also measured and recorded. The butt was then cut off flush with the base of the next lowest petiole and that petiole removed as described above.

The results of these tests are shown in figure 14. The required detachment force versus petiole width is plotted for celery stalks with and without the butt protruding below the base of the lowest petiole. Statistical analysis again showed no difference in mean detachment force or variance between the two treatments.

Commercial Tests

After it had been established that the machine-assisted method of stripping celery stalks did not adversely affect the final size of the stripped celery stalks and did not loosen petioles remaining on the stalk, research was conducted in a commercial packinghouse. The equipment used in this phase of the research was a commercial celery butt trimmer (fig. 15). It consisted of a rotating disk, equipped with a replaceable blade, recessed in the center of a "rubber doughnut" guard. The disk was attached directly to an electric motor shaft and rotated at 1,725 revolutions per minute.

This type of butt trimmer has been commonly used after the celery stalks have been stripped, to remove any root growth or excess butt material. When moved to the stripping line, however, it is just as effective in removing petioles from celery stalks as the experimental equipment. The butt end of the stalk is pushed against the rotating disk, as shown in figure 16, and slight pressure is applied until the desired number of petioles have been removed. The petioles are allowed to drop into the trash chute and the stripped stalk is placed on the stripped stalk conveyor.

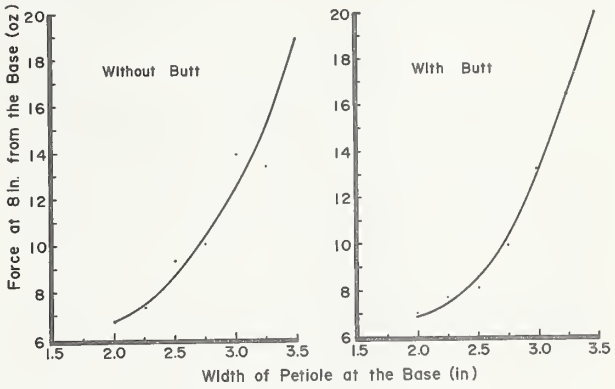

FIGURE 14.—Force required to remove outer petioles from stripped celery stalks.

FIGURE 15.—Celery butt trimmer used for stripping celery stalks.

FIGURE 16.—Worker stripping celery stalk with celery butt trimmer.

LABOR AND EQUIPMENT

A qualified worker stripping celery stalks by hand averages 8 stalks per minute, with a range of 4 or 5 to approximately 14 stalks per minute, depending upon the number of petioles to be removed. Stalks such as those shown in figure 5, which require very little stripping, could be handled at a rate of 12 to 14 per minute. The stalk shown in figure 6, on the other hand, is at the other extreme and would require much more time to strip by hand.

Workers using the machine-assisted method can average 12 stalks per minute. Fluctuations in output rate caused by the number of petioles to be removed are held to a minimum because the motions required are essentially the same regardless of the number of petioles to be removed.

The average output per worker on the stripping line can be increased from 8 stalks per minute to approximately 12 stalks per minute by using the machine-assisted method at approximately one-half of the work stations. The equipment should be installed toward the incoming end of the line so that workers using the machine-assisted method can select the stalks containing the most petioles. Workers stationed further down the line can hand-strip the remaining stalks, which have few petioles, at a rate equal to that of the machine-assisted method.

The equipment used at the machine-assisted stripping stations can be either commercial celery butt trimmers or equipment similar to the experimental equipment used in the early field studies (fig. 9). If the experimental equipment is selected, it can be assembled by packinghouse personnel by attaching a 10-inch blade directly to the motor shaft. A safety housing must be placed around the blade to protect workers from injury. A ⅓-horsepower motor should be large enough to provide continuous-duty operation.

A commercial butt trimmer will cost around $200 installed on the stripping line. The cost of a trimmer similar to the experimental model should be less—approximately $150. Either machine represents an extremely low investment and should be relatively maintenance free.

Compared with hand stripping, labor requirements can be reduced by one-third with the machine-assisted method of stripping celery stalks. This means that for a line handling 200 stalks per minute, the number of workers could be reduced from 25 to approximately 17.

Assuming that the packinghouse will operate 1,500 hours a year and pay an average wage of $2.50, the annual savings in labor costs will be $30,000 with the machine-assisted method of removing petioles.

ACKNOWLEDGMENT

Grateful acknowledgment is made to John C. Teele, industrial engineering technician, who constructed the research equipment and assisted in collecting the data required for this report.

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